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TTCS Differential Pressure Sensors Specification and Statement of Work

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Summary

This document specifies the requirements and Statement of Work for the Differential Pressure Sensors (DPSes) for the AMS-02 Tracker Thermal Control System

Contents

(23 pages in total)

1 Introduction

1.1 Objective of this document

The objective of this specification is to define the requirements for the Differential Pressure Sensors (DPSes) for the AMS Tracker Thermal Control System (AMS TTCS) CO_2-cooling loop.

The requirements are based on the AMS-02 Tracker Thermal Control System design requirements and on general requirements on space hardware on board ISS and STS.

1.2 Reference documents

RD.nr	Document Title	
RD.1.	Requirements for the manufacturing and space qualification of all the pressurised weld joints in the AMS TTCS evaporator, revision B, B. Verlaat, 2 Sept. 2003	ASR-S-001
RD.2.	NASA- document "Simplified Design Options for STS-Payloads"	JSC-2045RevA
RD.3.		
RD.4.		

1.3 Background: AMS-02 Tracker Thermal Control System

The Alpha Magnetic Spectrometer -02 (AMS-02) is a space born detector for cosmic rays built by an international collaboration. AMS-02 will operate aboard the truss of the International Space Station (ISS) for at least 3 years, collecting several billions of high-energy protons and nucleï. The main goal is to search for cosmic antimatter, (that is for anti-helium nuclei primarily), for dark matter and lost matter.
In AMS-02, an active thermal control system is required to meet the stringent electronics temperature stability requirements of the detector electronics.
The AMS-02 Tracker Thermal Control System (TTCS) is a two-phase cooling system developed by NIKHEF (The Netherlands), Geneva University (Suisse), INFN Perugia (Italy), Sun Yat Sen University Guangzhou (China) and NLR (The Netherlands).

The TTCS is a mechanically pumped two-phase carbon dioxide (CO_2) cooling loop. The main objective is to provide accurate temperature control of AMS Tracker front-end electronics.
The two-phase loop incorporates a long evaporator, picking up the heat from multiple heat-input stations. The heat is transported to condensers connected to heat pipe radiator.

The objective of the cooling system is to collect the dissipated heat at the tracker electronics and transport the heat to two dedicated radiators.

1.4 Differential Pressure Sensors in TTCS

The TTCS loop is temperature controlled. Pressure and temperature are related in the two phase environment. The absolute system pressure varies with the loop temperature from 6 bar (- 50 ^{0}C) until 65 bar (+ 25 ^{0}C)

The DPSes are used to measure the total pressure drop over the system, which varies with the system flow rate:

- minimum CO_2 flow rate 1 ml/s: 150 mbar
- maximal CO_2 flow rate 4 ml/s: 850 mbar

The challenge for the differential pressure sensors is to produce accurate (TBD) measurements of the small pressure drop over the pump, in the presence of a high line pressure.

1.5 Requirements Verification methods

The requirements specified in chapter 3 are to be verified by one or more of the following methods:

verif. ident	the requirement is verified by
D	design review, inspection of the design, design calculation etc
S	similarity; the valve design is similar or identical to an existing valve which can be shown to satisfy the requirement
T	test or test campaign
I	inspection
R	review
nt	not traceable

Table 1-1 Table of requirements verification methods

2 Statement of Work for the Differential Pressure Sensors

2.1 Hardware and documentation deliverables and need dates

The numbers of sensors to be delivered and their need dates are given below in Table 2-1.

Table 2-1 Table of DPSes to be delivered

delivery	quantity	DPS model	Need date
1. EM	3	EM	01-06-2005
2. EQM	1	EQM [1])	01-06-2005
3. QM	3	QM	01-12-2005
4. FM	5	FM	01-02-2006

[1]) EM and EQM are identical and are to be manufactured in one batch. One DPS is to be subjected to a sensor qualification programme, see below, section 2.2.

2.2 Sensor qualification programme

One DPS of the EM/EQM delivery is to be subjected to a qualification programme by the manufacturer.

The sensor qualification programme shall encompass the following tests:

- thermal vacuum cycling tests: verification of operation in vacuum, see section 3.5.1, and of high and low operating and storage temperatures, see section 3.5.2
- external leak-tightness tests: verification of requirements, see section 3.5.5
- EMC tests: verification of emitted EM and EM susceptibility, see section 3.5.6.1
- proof pressure tests: verification of requirements, see section 3.5.8.1.
- random vibration tests and shock tests: verification of requirements, see section 3.5.8.2 and 3.5.8.3.

Tests may be skipped -after approval by the customer-, if similar or better qualification test results for the offered sensors are available.

In his price offer the manufacturer shall make a separate quotation for the above qualification tests.

Finally the following test shall be executed:

- Verification of operation of the sensors in a strong magnetic field, requirement see section 3.5.6.2

In his price offer the manufacturer shall make a separate quotation for this test.

The requirements listed in Chapter 3 shall be verified on all sensors according to the indicated verification methods.
However, the requirements referred to in the above qualification programme need to be verified by test, only on the single DPS EQM model (as far as no similar existing qualification tests results for the offered sensors are available) and are considered satisfied by the other sensors by similarity (S).

After successful qualification of the EQM sensors and approval of the customer, the actual QM sensors may be produced. The QM sensors will be used in the TTCS-QM model, which will be subjected to qualification programme by the customer, similar to the qualification programme specified above.

After a successful sensor operation during the TTCS-QM campaign and approval of the customer, the FM sensors may be manufactured.

The design, materials and manufacturing of the sensors EM EQM QM, FM shall be the same. Also the electronics parts shall be flight quality (and therefore space qualified) parts.

2.3 Deliverable documentation

Title	Responsible	Delivery (date, day-month-year)
Engineering documentation		
TN Safety Aspects Pressure sensor design [1])	Contractor	21-02-2005
TN Pressure Sensors Design Including: mechanical (dimensions, envelope weight) characteristics Interface control drawings Electrical drawings power consumption Matrix of compliance (by design, or similarity) with requirements specification Component list Mechanical parts list Material list As built configuration data	Contractor	21-02-05 (DDR-2 months)
Design drawings	Contractor	21-02-05 (DDR-2 months)
EQM Sensors Verification Plan	Contractor	21-02-05 (DDR-2 months)
EQM Sensors Test procedures	Contractor	21-02-05 (DDR-2 months)
EQM Sensors Test Report including matrix of compliance (by test) with requirements specification	Contractor	01-06-2005
Sensor Design QM (possibly modified/revised)	Contractor	20-08-2005
Design Drawings QM	Contractor	20-08-2005
delivery manufacturing documentation and QM sensors	Contractor	01-12-2005
Sensor Design FM (possibly revised/modified)	Contractor	20-10-2005

Design Drawings FM	Contractor	20-10-2005
delivery manufacturing documentation and FM sensors	Contractor	01-02-2006
Management Documentation		
Progress reports	Contractor	Inputs on request
Schedule reporting	Contractor	Inputs on request

[1]) Fill-in forms with the required information will be supplied by the customer.

2.4 Sensors acceptance programme

2.4.1 EM and EQM sensors acceptance

The EM and EQM sensors are to be manufactured in one batch and will be accepted after:

- approval of the design documentation by the customer,
- definition of the sensors qualification test programme , depending on the qualification status of available valve designs, by the manufacturer and approval of the programme by the customer
- successful conductance of the sensors qualification programme (and possibly delta qualification) by the manufacturer and approval by the customer
- delivery of the design and manufacturing documentation and EM and EQM sensors to the customer
- successful operation of the EM sensors in the EM loop.

2.4.2 QM sensors acceptance

The QM sensors for the TTCS QM loop will be released for manufacturing by the customer, after successful acceptance of the EM, EQM sensors.

The QM sensors are to be manufactured in one batch and will be accepted after:

- satisfactory operation of the sensors during the TTCS-QM box qualification programme executed by the customer
- (possibly) successful delta qualification by the manufacturer, if deemed necessary from TTCS QM box test results.

2.4.3 FM sensors acceptance

The FM sensors for the TTCS FM loop will be released for manufacturing after successful acceptance of the QM sensors. The FM sensors are to be manufactured in one batch and will be accepted after:

- delivery of the design and manufacturing documentation and the sensors to the customer
- successful incoming inspection
- successful operation in TTCS FM

3 Differential Pressure Sensors Requirements Specification

3.1 Functional requirements

3.1.1 DPS Type: Transducer or Transmitter (Req. id. DPS-001, Verif. D, T)

The Differential Pressure Sensors (DPSes) may be differential pressure transducers or differential pressure transmitters. In the latter case, also the transmitter electronics shall meet the relevant requirements specified in this document.

3.1.2 DPSes measurement range and accuracy. (Req. id. DPS-002, Verif. D, T)

The DPSes shall be able to measure the pressure drop over the CO_2 loop, within a range from 10 mbar until 1000 mbar, where the absolute pressure may be in a range from 6 bar until 65 bar. The accuracy shall be 0.5 % of full scale.

3.2 Physical requirements

3.2.1 Mass (Req. id. DPS-003, Verif. D, T)

The DPSes shall be as lightweight possible, with a maximum of 0.2 kg.

3.3 Mechanical Interfaces

3.3.1 Dimensional envelope (Req. id. DPS-004, Verif. D)

The maximum dimensional envelope of a DPS shall be less then: h x w x b = 100*100*100 mm.

3.3.2 Mounting interfaces (Req. id. DPS-005, Verif. D)

The DPSes shall be equipped with a mounting interface, such that they can be bolted into the TTCS box.

3.3.3 Interface with loop tubing (Req. id. DPS-006, Verif. D)

The DPSes shall provide a welding interface to the TTCS loop tubing.

- The dimensions of the connection tubing is stainless steel D_i=2.6 mm D_o = 4mm.
- Material should be 316L CRES for orbital welding to the TTCS tubes.
- Enough interface length shall be available, to account for the welding procedure defined in RD-1.

3.4 Electrical interfaces

3.4.1 No Grounding loops. (Req. id. DPS-007, Verif. D, T)

The electrical interfaces shall be such that no unwanted grounding loops can occur. Power and signal leads shall be floating, i.e. isolated from common and/or safety ground.

3.4.2 Supply voltage. (Req. id. DPS-008, Verif. S orT)

The on-board supply voltage is 28 V.
It shall be possible to operate the DPSes at a voltage less than 28 V.

3.4.3 Power consumption. (Req. id. DPS-009, Verif. S or T)

Power consumption of a DPS shall be less than 1 Watts

3.5 Environmental Requirements

3.5.1 Operation under vacuum conditions (Req. id. DPS-010, Verif. S or T)

The DPSes shall be able to operate in high vacuum < ($1*10^{-6}$ mbar)

3.5.2 Operating and non-operating temperatures

3.5.2.1 Operating temperatures. (Req. id. DPS-011, Verif. S or T)

The allowable operational temperature range of the DPSes shall be from – 40 ˚C upto +60˚C or better.

3.5.2.2 Non-operating temperatures (Req. id. DPS-012, Verif. S or T)

The allowable storage and non-operating temperature range of the DPSes shall be from –60 ˚C upto + 80 ˚C or better.

3.5.3 Operation in μ-g environment. (Req. id. DPS-013, Verif. S or T)

The DPSes shall be able to operate in μ-g environment.

3.5.4 Orientation (Req. id. DPS-014, Verif. S or T)

The DPSes shall be able to provide full operational performance during ground testing, in arbitrary orientations.

3.5.5 External leak tightness. (Req. id. DPS-015, Verif. T)

The leak tightness shall be lower than $1*10^{-8}$ mbar*l/s CO_2 at 160 bar.

3.5.6 Electro Magnetic Compatibility

3.5.6.1 Compliance with ISS EMC requirements. (Req. id. DPS-016, Verif. S or T)

The DPSes shall be compliant with the EMC requirements for AMS-02. The applicable AMS-02 EMC requirements are based on the ISS (external site) EMC requirements specified in SSP 30237, Rev. F. The requirements (EMC levels and tests) from SSP 30237, Rev. F applicable for AMS-02 and hence for the DPSes, are listed in this present specification, see Appendix II, Table 3-5 Table of EMC requirements applicable to AMS-02

In the Appendix II Table 3-5 the applicable requirements are listed for:

- conducted and radiated emission and
- conducted and radiated susceptibility

The DPSes supplier shall warrant that the DPSes satisfy the EMC requirements.

The EMC requirements shall be verified by test (T), according to SSP 30237, Rev. F or by similarity (S) if the proposed DPS type has undergone similar tests.

The DPSes will be integrated in a TTCS qualification model, which will be subjected to the above specified EMC tests.

3.5.6.2 Compliance with AMS-02 magnetic field.(Req. id. DPS-017, Verif. T)

The DPSes are located in the strong magnetic field generated by the AMS cryogenic cooled magnet. The DPSes shall be able to operate within a magnetic field between 140 and 1000 Gauss, depending on its final location inside the TTCS component boxes.

The operation of the DPSes, -in various orientations w.r.t. the magnetic field and various relevant field strengths-, shall be verified by the manufacturer in the AMS magnetic field test facility at MIT in Boston.

If required for reliable operation of the DPSes, use can be made of magnetic shielding materials (Vacoflux: soft magnetic cobalt-iron alloys).

The tests can be conducted at MIT, by the DPSes manufacturer, free of charge. However, a test set-up and a test engineer to execute the tests must be made available.

In his price offer, the manufacturer shall make a separate quotation for this magnetic field susceptibility test.

3.5.7 Cosmic radiation levels. (Req. id. DPS-018, Verif. D or S or T)

The DPSes materials and electronics shall withstand a TBD cosmic radiation level.

3.5.8 Structural verification requirements

3.5.8.1 Proof pressure.(Req. id. DPS-019, Verif. S or T)

The DPSes shall be subjected to a proof pressure test. The proof pressure shall be 1.5 times the maximum design pressure (MDP), (MDP = 160 bar).

3.5.8.2 Vibration requirements (Req. id. DPS-020, Verif. S or T)

The DPSes shall be to endure without loss of function, a random vibration test, according to the Minimum Workmanship levels specified for AMS-02, see this specification Appendix 1, section D.

3.5.8.3 Shock test requirements (Req. id. DPS-021, Verif. S or T)

The DPSes shall be able to endure a shock of 20 g, without loss of function.

3.6 Design Requirements

3.6.1 Structural design requirements. (Req. id. DPS-022 , Verif. D)

The TTCS and hence the DPSes are pressurised during STS launch. Therefore, the DPSes shall satisfy the NASA- document JSC-2045, Rev.A (Simplified Design Options for STS-Payloads), taking into account that the DPSes are pressurised vessels.
A summary of the structural design and verification requirements is given in appendix 1.

3.6.1.1 Design loads and safety factors.(Req. id. DPS-023, Verif. D)

A design load (e.g. for the DPSes mounting flanges/interfaces) according to Table 3-2 is to be taken into account.
A load ultimate factor of safety FSu > 2.0 shall be applied, such that no load testing needs to be done.

3.6.1.2 Line Working pressure. Req. id. DPS-024, Verif. S or T)

The DPSes shall be able to operate according to specification, in a line working pressure range for the DPSes is from 6 bar upto 65 bar.

3.6.1.3 Maximum Design Pressure. (Req. id. DPS-025, Verif. D)

The maximum design pressure (MDP) shall be 160 bar, at temperature of + 80 °C.

3.6.1.4 Proof pressure. (Req. id. DPS-026, Verif. D)

The proof system pressure shall be 1.5 times the maximum design pressure (MDP).

The pressure sensors shall be able to withstand the proof pressure without performance degradation.

3.6.1.5 Burst pressure. (Req. id. DPS-027, Verif. D, S or T)

The burst pressure shall be at least 2.5 times the maximum design pressure (MDP).

3.6.1.6 Rupture. (Req. id. DPS-028, Verif. D, S or T)

The DPSes shall be designed to leak before burst.

3.6.2 Working fluid compatibility. Req. id. DPS-029, Verif. D or S)

The used materials shall be compatible with Carbon Dioxide (CO_2) and IPA (IsoPropylAlcohol)

3.6.3 Lifetime (Req. id. DPS-030, Verif. D, or S or T)

The DPSes shall meet the following lifetime requirements after equipment acceptance testing.

- 1 year storage on ground
- 3 months operation on ground (AMS Tracker test)
- 3 years of operation in orbit

3.6.4 Maintenance (Req. id. DPS-031, Verif. D or S)

The DPSes shall not require any maintenance.

3.6.5 Prohibited materials. (Req. id. DPS-032, Verif. D)

The usage of the following materials on the DPSes, including its electrical connectors, is prohibited: Beryllium, beryllium alloys and oxides, cadmium and zinc. Chlorinated cleaning agents shall not be used during manufacturing, testing, storage or other handling.
Polyvinyl chloride products shall not be used.

3.7 Product assurance and Quality management

3.7.1 Audits (Req. id. DPS-033, Verif. R)

The customer is entitled to perform quality audits at the manufacturer's premises.

3.7.2 Materials traceability. (Req. id. DPS-034, Verif. I)

Materials and parts traceability shall be provided from the incoming inspection at the contractor until the delivery to the customer.

3.7.3 Serial numbers (Req. id. DPS-035, Verif. I)

The DPSes shall each have a unique serial number specified by the manufacturer. The serial number shall be visible at the outside surface.

3.7.4 Cleanliness requirements (Req. id. DPS-036, Verif. T)

The DPSes shall not contaminate the system working fluid

Loose metallic particles are not allowed. The cleanliness of the DPSes shall be checked by rinsing the DPSes with IPA (IsoPropyl Alcohol). The maximum number of non-metallic particles in a 100 ml sample shall be as follows and is equivalent to MIL-STD-1246 C class 100:

- > 100µm none
- 100 µm 5 max
- 50 µm 50 max
- 25 µm 200 max
- 10 µm 1200 max
- 5 µm no limit

3.8 Export license (Req. id. DPS-037, Verif. I)

The TTCS will be integrated at the Sun Yat Sen University in China. Therefore, the manufacturer shall warrant (in writing) that export to China is allowed, and if required, shall supply an export license.

Appendix 1: TTCS Structural Design and Verification Requirements Summary

For a Space Shuttle payload like AMS-02 design rules as given in this document must be applied to design sub-systems like the TTCS and its components.
The TTCS is a so-called secondary structure component and must be designed according to information in this document to survive launch, orbit and landing.
The TTCS will be a system, which contains pressurized fluid inside; this means that also the rules for pressurized systems must be applied.
The design criteria summarized in this document must be met to get a NASA safety approval.
Additional verification might be done for a mission success point of view.
For a NASA approval it is also important to list the materials used.
Using the wrong materials might harm the experiment or the neighbouring environment, due to out gassing or atomic oxygen degeneration.
The second part of this document lists the main components of the TTCS and their structural verification and material use.
This document is subject to continuous change following the development of the design of the TTCS.

A: Structural design loads and verification requirements:

Ultimate load = Ultimate factor of safety x Limit load

Yield load = Yield factor of safety x Limit load

A1: The "Ultimate load" is the load, which causes rupture to the mechanics.

A2: The "Yield load" is the load, which causes yield to the mechanics.

A3: The "Ultimate factor of safety" (FSu) and the "Yield factor of safety" (FSy) are the safety factors needed to calculate the "Ultimate load".

These factors are:

No testing required	**Testing required**
FSu > 2.0	1.4 < FSu < 2.0
FSy > 1.25	1.1 < FSy < 1.4

Table 3-1 Table of FSu and FSy factors

When the component design is such that safety factors are in the right column marked as "Testing required" the flight component need to under go testing.

A4: The "Limit load" is the maximum load a structure will be exposed to during launch, orbit and landing. The limit load is defined as:

Limit load = Load factor x Weight

A simple way of deriving the load factor for a components is according to the following table:

component weight	load factor (g)
<20	40
20-50	31
50-100	22
100-200	17
200-500	13

Table 3-2 Load factors to be applied to TTCS and its components

These load factors need to be applied in any axis with a load factor equal to 25% applied to the 2 orthogonal axes simultaneously.

A5: First resonance frequency higher than 50 Hz
All hardware components shall have a first resonance frequency higher than 50 Hz, than no dynamic tests are required. If the resonance frequency is lower than 50 Hz but higher than 35 Hz, a sine sweep, smart hammer or modal testing is required.

B: Structural design and verification requirements for pressurised systems:

Ultimate pressure = Ultimate pressure factor x MDP

B1: Where "MDP" stands for "Maximum Design Pressure". MDP for a pressurised system shall be the highest pressure defined by the maximum relief pressure, maximum regulator pressure or maximum temperature.

B2: The "Ultimate pressure factor" is a multiplying factor applied to the MDP to obtain ultimate pressure. Pressurised components are to be designed to the following factors of safety.

Lines and fittings	Burst	Proof
diameter <1.5"	4.0	1.5

diameter => 1.5"	2.5	1.5
Other components	2.5	1.5

Table 3-3 Table of burst and proof pressure factors

B3: In case of a pressurised system, the loads caused by the ultimate pressure needs to be added to the ultimate load caused by vehicle acceleration.

B4: To test the system for evidence of satisfactory workmanship, a proof pressure needs to be applied.

Proof pressure = Proof factor x MDP

The proof factor is determined in table 3.

Pressurised components shall sustain the proof pressure without detrimental deformation.

C: Fracture analysis:

C1: Pressurised components or sealed containers that have a non hazardous Leak-Before- Burst (LBB) mode of failure may be classified as low risk fracture parts.

C2: Components in a sealed box do not need structural verification when it can be proved that the released parts are completely contained and will not cause a catastrophic hazard.

C3: All fasteners larger than M3 (US #8 and above) are subject to NASA structural testing. It is recommended to use NASA provided MS- or NASA- fasteners.

D: Random vibration requirements: Minimum Workmanship Vibration Test Levels

axis	**frequency**	**level**
all axes Test duration 60 seconds per axis	< 20 Hz	0
	20 Hz	0.01 g^2/Hz
	20-80 Hz	increasing 3 dB/Octave
	80-500 Hz	0.04 g^2/Hz
	500-2000 Hz	decreasing 3 dB/Octave
	2000 Hz	0.01 g^2/Hz
	> 2000 Hz	0

Table 3-4 Table of Minimum Workmanship random vibration test levels

Appendix 11: EMC requirements applicable to AMS-02

EMC Requirements Applicable to AMS-02

Type of Test/Requirement	Name of Test	Coverage	Applicability to AMS-
Conducted Emissions	SSP 30237, Rev F CE01	DC power, lo freq, 30 Hz to 15 kHz.	Required
Conducted Emissions	SSP 30237, Rev F CE03	DC power, 15 kHz to 50 MHz.	Required
Conducted Emissions	SSP 30237, Rev F CE07	DC power leads, spikes, time domain.	Required
Conducted Susceptibility	SSP 30237, Rev F SSP 30237 SSCN 3282 D.2 CS01	DC power leads, 30 Hz to 50 kHz.	Required
Conducted Susceptibility	SSP 30237, Rev F SSP 30237 SSCN 3282 D.2 CS02	DC power leads, 50 kHz to 50 MHz.	Required
Conducted Susceptibility	SSP 30237, Rev F SSP 30237 SSCN 3282 D.2 CS06	Spikes, power leads.	Required
Radiated Emissions	SSP 30237, Rev F RE02	Electric field, 14 kHz to 10 GHz (narrowband), 13.5 -15.5 GHz.	Required
Radiated Susceptibility	SSP 30237, Rev F RS02	Magnetic induction field	Desired by EP4/JSC
Radiated Susceptibility	SSP 30237 SSCN 3282 PIRN 57003-NA-0023 RS03PL	Electric field, 14 kHz to 20 GHz.	Desired by EP4/JSC

Table 3-5 Table of EMC requirements applicable to AMS-02

An excerpt from the applicable SSP 30237 SSCN 3282 PIRN 57003-NA-0023 RS03PL mentioned in the above table for radiated susceptibility, is given below.

ISS PAYLOAD OFFICE IRN/PIRN/EXCEPTION

Doc. No., **SSP 57003, Initial Release**

Rev. & Title: **Attached Payload Interface Requirements Document**

PIRN NO: **57003-NA-0023**

(P)IRN TITLE: **Relaxation of EMI RS03 Requirement Per SSCN 3282**

SSCN/CR SSCN 3282

Agency Tracking No.: 57003-0026

SYSTEM/ELEMENT AFFECTED & STAGE EFFECTIVITY: **EME**

REASON FOR CHANGE: (INCLUDE APPLICABLE ICAP NUMBER):

Relaxation of RS03 requirements in accordance with SSCN 3282 .

PARAGRAPHS, FIGURES, TABLES AFFECTED (For PIRN use only)

Page **3-27**

Paragraph(s) **3.2.2.4.4**

From:

3.2.2.4.4 ELECTROMAGNETIC INTERFERENCE

Payload EPCE shall meet all Electromagnetic Interference (EMI) requirements of SSP 30237.

To:

3.2.2.4.4 ELECTROMAGNETIC INTERFERENCE

Attached Payloads shall meet all Electromagnetic Interference (EMI) requirements of SSP 30237.

Alternately, Attached Payloads may choose to accept a minimal increase of EMI risk with a somewhat less stringent Electric Field Radiated Susceptibility (RS03) requirement on equipment considered to be non-safety critical to the vehicle and crew. The tailored RS03 requirement, shown below, will hereafter be denoted RS03PL.

FREQUENCY	**RS03PL LIMIT (V/m)**
14 kHz - 400 MHz	5
400 MHz - 450 MHz	30
450 MHz - 1 GHz	5
1 GHz - 5 GHz	25
5 GHz – 6 GHz	60
6 GHz – 10 GHz	20
13.7 GHz – 15.2 GHz	25

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